UNIVERSIDADE FEDERAL DE LAVRAS

MATHEUS CASTILHO GALVÃO

LONG TERM EFFECTS OF THE USE OF CREEP-FEEDING FOR BEEF CALVES UNDER TROPICAL CONDITIONS

Lavras - MG
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Dissertation presented to the Universidade Federal de Lavras, as part of the requirements of the Graduate Program in Animal Science, area of concentration in Production and Nutrition of Ruminants, to obtain the title of Master.

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Aos meus amigos e família, em especial a minha vó Luzia, que hoje é uma estrela no céu, que ilumina nossos caminhos.

Dedico

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“As pessoas costumam dizer que a motivação não dura para sempre. Bem, nem o efeito do banho, por isso recomenda-se diariamente.”

Zig Ziglar

Summary

FIRST CHAPTER

ABSTRACT: The objectives of this study were: to verify the systemic effects of the use of *creep-feeding* into beef cattle production system on weight variation of cows, the performance, intake and digestibility of calves during the suckling phase and also the residual effect in the post weaning phase. Thirty-six pairs of cows: calves [(year 1: 9 females and 9 males); (year 2: 14 females and 4 males), with initial weight of 550 ± 48 and 35.6 ± 5.5 kg, respectively, were used. The experimental design was completely randomized, factorial 2x2 (two treatments, control and *creep-feeding* and two calf sex, male and female). Experiment was divided into two phases: suckling (pre-weaning) phase and post-weaning phase. At pre-weaning phase, the animals were kept in an area of 6.2 hectares, divided into 20 paddocks (3,100 m2 each), composed of *Brachiaria brizantha*. The supplemented treatment calves received concentrated feed at the 0.7% level of BW daily. Milking of cows was performed monthly to estimate the milk intake of calves. Three behavioral trials were carried out along the suckling phase, evaluating the activities of grazing, idle rumination, and suckling time. At post-suckling phase, the calves were separated by sex and both received supplementation during the evaluation periods (winter, spring and summer) until they achieved 18 months of age. The level of supplementation for winter/spring and summer was 0.5% and 0.3% of BW, respectively. Supplemented calves weaned heavier than control ($P < 0.001$). The same happened for sex, with male weaned heavier ($P<0.001$) and intake more milk than females ($P < 0.0001$). Supplementation reduced forage and milk intake of calves ($P<0.097$ and $P<0.001$, respectively) during the pre-weaning phase. Regarding to the behavior, supplemented animals spent less time grazing over time than control ($P<0.020$). At the post-weaning phase, animals that received creep-feeding during the pre-weaning phase were heavier during winter ($P = 0.010$) and spring ($P = 0.080$) but not at the end of experiment (18 months) ($P = 0.291$). Males ate more forage than females during rearing periods ($P \leq 0.089$) gain more weight ($P < 0.0001$). There was no effect on supplement intake at any phase of the experiment ($P \geq 0.172$), butt males gain more weight in all experiment phase ($P < 0.0001$). The use of creep-feeding increased the weight gain in the breeding phase tends to be higher in males, males intakes more milk than females,but in the rearing, this gain tends to be partially lost.

KEY WORDS: beef cattle**,** *Bos taurus indicus*, milk production, supplementation

RESUMO: Os objetivos deste estudo são: verificar o efeito do uso de creep-feeding no sistema produtivo e na variação de peso das vacas e desempenho; consumo e diestibilidade dos bezerros durante o período de lactação e seu efeito residual na recria. Trinta e seis pares vacas:bezerros [(ano 1: 9 fêmeas e 9 machos); (ano 2 : 14 fêmeas e 4 machos)], com peso inicial de 550 ± 48 e 35.6 ± 5.5 kg foram utilizadas, respectivamente. O delineamento experimental foi inteiramente casualizado, fatorial 2x2 (dois tratamentos; controle e creep-feeding e dois gêneros; macho e fêmea). Experimento foi dividido em duas fases: lactação e recria. Na lactação, os animais ficaram em uma área de 6.2 hectares, divididos em 20 piquetes (3.100 m^2 cada) composto por *Brachiaria brizantha*. Os bezerros do tratamento suplementado receberam alimento concentrado ao nível de 0.7% do PV diariamente. Mensalmente foi realizada ordenha das vacas para estimar o consumo de leite dos bezerros. Três ensaios de comportamento foram realizados ao longo da cria, avaliando as atividades de pastejo, ruminação ócio e tempo de mamada. Na recria, os bezerros foram separados por gênero e ambos receberam suplementação durante os períodos de avaliação (inverno, primavera e verão) até atingirem 18 meses de idade. O nível de suplementação para inverno/primavera e verão foi de 0.5% e 0.3% do PV. Bezerros suplementados desmamaram mais pesados que o controle (P<0.001). O mesmo aconteceu para o sexo, onde macho desmamou mais pesado (P<0.001) e consumiram mais leite que as fêmeas (P < 0.001). Suplementação reduziu o consumo de forragem e leite dos bezerros (P <0.097 e P<0.001, respectivamente) durante a fase de cria. Quanto ao comportamento, animais suplementados passaram menos tempo pastejando ao passar do tempo que os controle (P<0.020). Na recria, animais suplementados foram mais pesados durante o período do inverno (P=0.010) e primavera (P=0.080), porém, não houve diferença no verão (P ≥ 0.172), porém machos ganharam mais peso ao longo de todo experimento (P < 0.0001). Machos comeram mais forragem que fêmeas durante os períodos da recria (P≤0.089). O uso de *creep-feeding* aumentou o ganho de peso na fase da cria tendendo a ser maior nos machos, o consumo de leite foi maior para bezerros machos, na recria o ganho adicional tende a ser parcialmente perdido.
PALAVRAS CHAVE: *Bos taurus indicus*, bovino de corte, produção de leite, suplementação

1. Introduction

The zebu breeds (*Bos taurus indicus*) corresponds to 80% of the beef cattle herds in Brazil (Brazilian Beef Exporters Association - ABIEC, 2015) and are the main sources of beef in tropical countries (VALADARES FILHO et al., 2016). It is estimated that the Brazilian beef cattle herds reached 209.13 million heads in 2016 (ABIEC, 2016).

According to the data from ABIEC (2016) 39.16 million bovine were slaughtered in 2015. However, from this total only 5.05 million of herds came from feedlots. It shows that Brazilian livestock is, in its large part, developed in grazing systems, as in the case of the breeding herds (bulls, cows and calves before to weaning) and reaning phase (from weaning until the finishing process begins).

It is known that in the main part of Brazil the forage production is unstable throughout the year. The rainy season, which coincides with the hottest period of the year, the highest rainfall rate and long photoperiod, it is where there is the greater growth of forage plants. Thus, this period represents the greater forage availability to the animals throughout the year. On the other hand, during the dry season, where rainfall, temperature and photoperiod reduces, plants growth decreases leading to a deficit in the availability of forage for animals.

Thus, the use of supplements for these animals is very important, because allows better results in weight gain ad the end of each phase. In the breeding herd, calves response to supplementation are most evident, due to the accelerated growth of the animals in that phase and associated with the amount of ingested milk (GOES et al. 2008).

Many studies show positive effect on the performance of supplemented calves in the lactation phase (Ítavo et al., 2007; Moriel and Arthington, 2013; Gomes da Silva et al., 2017) and the positive effect of supplementation on the later phases (post weaning) (Azambuja et al., 2008; Almeida et al., 2015; Lazzarini et al., 2016)

However, research involving the use of creep-feeding in grazing of beef cattle production system has concentrated its efforts in specific situations of the production cycle, verifying, almost always, the effects on the calf only until weaning (Bailey et al., 1991; Neumann et al., 2005; Gomes da Silva et al., 2017).

It is unclear how supplementation affects milk production of cows (Gomes da Silva et al., 2017), but it is known that the animal eating solid feeds present “early” development of the ruminal epithelium, favoring the beginning of forage intake and reduction in frequency and intensity of suckling (Oliveira et al., 2007).

Based on this, we hypothesized that the effect of creep-feeding is systemic, with residual effects on the performance of the animal in later stages post weaning (rearing and finishing phase) and also on the cows.

We also hypothesized also that the calves supplementation with creep-feeding can affect the milk production of cows and consequently their energetic state and also variations on body condition score (in a system with repeated use of creep-feeding in comparison to a system without the use of it).

We have also hypothesized that creep-fed calves have higher liver energy spent after weaning when compared to non-creep-fed ones, which could be measured by the mRNA abundance of some markers in the liver tissue and could be useful to explain some differences in weight gain after weaning of creep and non-creep-fed animals.

Also, the parameterization of the possible effects of creep-feeding on the production system can provide subsidies for real economic evaluation of the benefits of using this practice in beef cattle production systems.

Therefore, the objectives of this study are: to verify the effects of the use of creep-feeding into beef cattle production system on productive variables of cows, to verify residual effects of creep-feeding on animal performance in the post weaning phase.

2. Background

2.1. Ingestive behavior of beef calves

2.1.1. Suckling behavior

The knowledge of the suckling behavior of calves contributes to the management and selection of cattle. Previously studies have shown that maternal milk accounts for a large part of the variation in weaning weight and weight gain from birth to weaning in beef calves (Rodrigues et al., 2016).

According to Day et al. (1987), several factors influence the suckling behavior of calves that will affect the milk production of cows, being genetic and environmental factors those the most relevant.

The performance of the calf throughout the lactation phase is associated with a higher frequency of suckling, and the suckling time reduces with age, regardless of the animal's genetic group (Rodrigues et al., 2016). Das et al., (2000) observed a reduction in the total duration of suckling over the age of the animal. One-month old calves spent, an average of 15.5 minutes suckling; but at 6 months of age, the time reduced to 7.3 minutes. These authors have also observed that the frequency of suckling reduced from the first to the sixth month of age.

Purebreed Zebu calves were shown to spent more time suckling (11.8 vs 9.4 minutes, respectively) and had also greater suckling rate (2.8 vs 2.2 times per day, respectively) than Zebu plus Taurine crossbred (DAS et al., 2000)

In addition to the genetic group of the animals, the sex of the calf also interferes with the suckling behavior. Rodrigues et al., (2016) working with pure and crossbreed zebu showed a higher frequency of suckling and time of suckling for males compared to females.

This fact was explained as a function of the fastest development of males in relation to females (NOGUEIRA et al., 2006).

However, in a study with buffaloes, Madella-Oliveira et al., (2010) did not observe a difference as to the frequency and time of feeding as to the gender of the progeny.

Galvão et al., (2013) working with supplemented zebu calves, observed a greater and suckling frequency for male calves, corroborating with that was observed by (Paranhos da Costa et al., 2006)

2.1.2. Grazing behavior

The grazing behavior is composed of some factors: such as grazing time, idle time and rumination time, the main components (Zanine et al., 2006), and knowing the main hours of cattle grazing are of great importance, because, it assists the technicians in the management of the pasture so that there is a better use of forage of the animal (FARINATTI et al., 2004).

For Van Rees et al., (1983), the most frequent times occur in the cooler periods on the day (beginning of the day or late afternoon), taking on average 6 to 11 hours a day (HODGSON et al., 1994).

Brâncio et al., (2003) observing the grazing behavior of Nelore calves found values of grazing time that varies between 8,3 and 11,3 ours.

The time of grazing is directly influenced by the characteristic of the canopy. Being height, density, botanical composition and spatial arrangement, the main factors (SOLLENBERGER & BURNS, 2001).

Observed the grazing behavior of crossbred calves under two different forages (*Brachiaria decumbens* and B*rachiaria brizantha*), Zanine et al., (2006) observed that the total grazing time, that is, adding the grazing time during the day, was higher for the calves that were found in *Brachiaria decumbens* pasture (11.31 and 9.75h). This reason can be explained due to the lower leaf:blade ratio, therefore, the animals becomes more selective and spends more time grazing. For Sarmento et al., (2003), selectivity and increase in grazing time are related as a compensatory mechanism.

In the same study, Zanine et al., (2006) also evaluated rumination and idle time, and didn’t observe a significant difference in total rumination time. Suggesting that the animals modify their grazing time as a way to regulate the intake of forage.

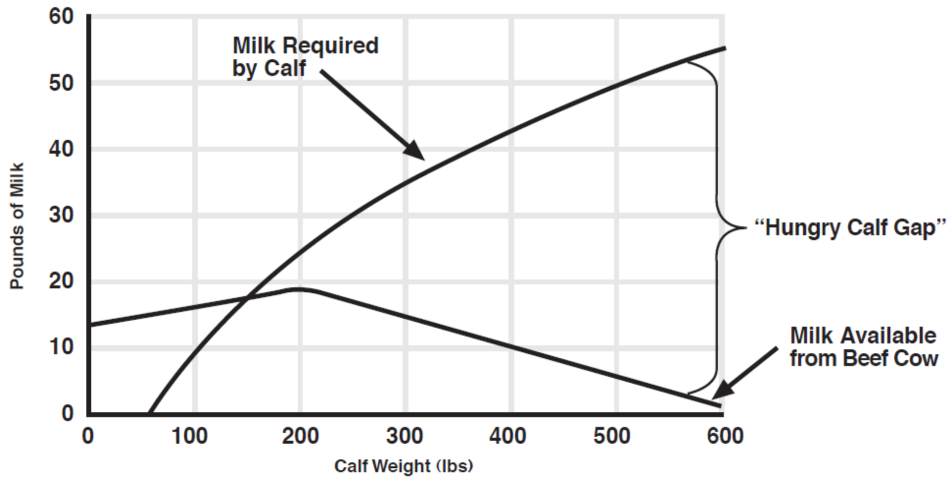
Another factor that changes the behavior is the genetic group of the calf. De Vargas et al., (2010) observed longer grazing time for crossbred calves when compared to pure zebu calves and, from the second month, the difference was greater, explained by the rapid development of crossbred animals, where the mother’s milk production doesn’t sufficiently meet their nutritional needs.

In their study with zebu supplements in the breeding phase, Galvão et al., (2013) observed a longer grazing time for animals that received supplementation, according to Church et al., (1980) the provision of solid diet for calves in the suckling phase, accelerate the ruminal development and with this, stimulate the consumption of forage.

2.2. Supplementation of suckling beef cattle

In beef calves, supplementation is a strategy to meet the reduction in milk production of cows associated with an increase in the nutritional requirement of suckling calves (RASBYet a., 2011), figure 1.

Figure 1 Relationship of cow's milk production with the nutritional requirement of the calf



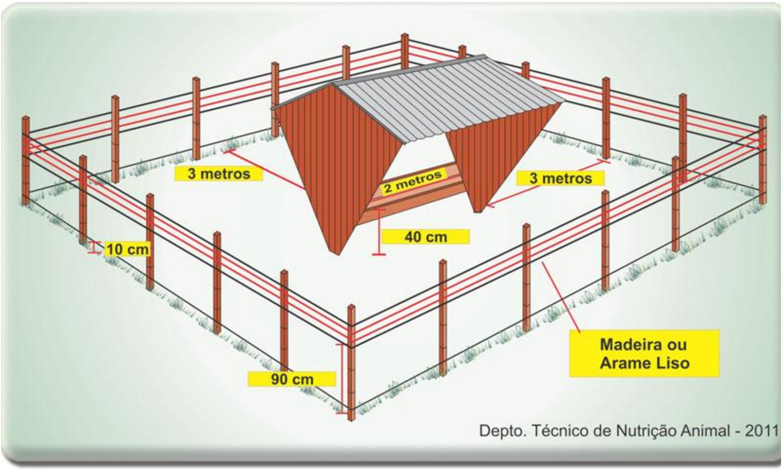
Source: Rasby et al., (2011)

Currently, there are two distinct techniques for providing exclusive supplement for calves, creep-grazing and creep-feeding. Creep-grazing is a technique rarely used in Brazil, it consists of a specific area within the pasture where only the calves have access. At this area, forage species of high nutritional value must be planted (VAZ PIRES et al., 2010). The technique called Creep-feeding is the most commonly used. This technique was adapted from the creation of dairy calves (VAZ PIRES et al., 2010).

Creep-feeding is a compound word, where animals receive concentrated supplementation in private pens without access from mothers (GOES et al., 2008).

This name was given because in the creep-feeding system, the lower boards are 10 cm from the ground and the upper boards are 90 cm from the ground (Figure 2), causing the calf to lower itself to have access to the private trough (DUARTE et al., 2007).

Figure 2 Creep-feeding model



Source: Matsuda, (2011)

It is important to emphasize that the private trough has to be installed near the source of water, mineral salt trough for the matrices, resting place, that is, where the animals spend more time (Rasby and Niemeyer, 2011).

According to Taylor & Field et al. (1999), the use of creep-feeding has some advantages and disadvantages, such as:

Advantages

- Higher body weight at weaning;
- Expression of genetic potential in improved animals;
- Increase in the marketing of improved animals;
- Reduced stress at weaning;
- Rest of the matrices.

Disadvantages

- Added body weight cost may be more expensive than a prescription;

- Delicate technique to be applied to replacement females;
- Little difference to the oversized animals that did not receive supplementation

Another positive point, which was cited by Goes et al. (2008), is that at this stage it is where the highest growth of cattle occurs, increasing the weight gain of the animals and providing a better use of the nutrients used by the animal.

Knowing the positive and negative effects of calf supplementation in the lactation phase, several studies were conducted to quantify the effect of supplementation at this stage, many studies show the positive effect of supplementation on animal weight gain.

Sampaio et al., (2002) observed higher weight gain in Canchim calves when supplemented with concentrated containing different levels of salt added (5% and 10% NaCl in the supplement), with 5% of addition Weight gain were higher (0.72 g. day -1 vs. 0.47 g. day -1).

In another study, however, evaluating different levels of supplementation, Neumann et al., (2005) observed greater weight gain for calves that received higher amounts of supplementation (1% and 1.25% of live weight).

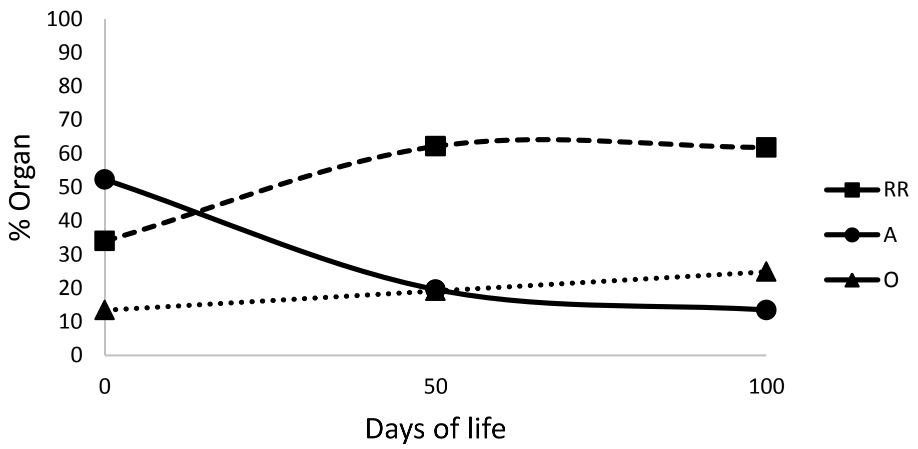
A similar result was found by Barros et al., (2015), where 3 different levels of supplementation were obtained and greater gain was observed in those animals whose level of supplementation was higher.

Neumann et al., (2005) evaluated the effect of supplementation on calf genotypes (male and female) and observed that males supplemented with higher supplementation levels presented higher final weight and weight gain when compared to females, or even when compared to calves that received a low level of supplementation (0.5% live weight).

In another study, however, evaluating the effect of adding or not supplementing, Nogeuria et al., (2002), as well as Neumann et al., (2005) observed greater weight gain and weaning weight gain in males when compared with Females. Having a difference between males that were supplemented or not. What explains the difference in weight gain is that the development of the male calves is faster than the females (NOGUEIRA et al., 2006)

Another advantage that can be highlighted is ruminal development. For Oliveira et al., (2007) the introduction of a solid diet for lactating calves favors the development of ruminal papillae especially if the diet is composed of solid foods, since it accelerates the process of keratinization of ruminal papillae such as the development of their muscles, as can be seen in Figure 3.

Figure 3 Development of the calf's stomach over time (RR, Rúmen-Reticulum; A, Abomasum; O, Omasum)



Source: adapted to Oliveira et al., (2007)

According to Oliveira et al. (2007), calves begin to consume solid diets with approximately two weeks of life, and at eight weeks, about 80% of the calf's stomach corresponds to rumen reticulum (proportion equal to that of animals adults).

In addition to the positive effects on ruminal performance and development. The supply of supplement makes the calf become independent earlier.

Supplementation promotes a reduction in pasture consumption by calves, thus increasing the availability and quality of the forage that will be ingested by the matrices (GOES et al., 2008).

Considering the production of precocious or superprecoce steers, Oliveira et al., (2007) commented that the adoption of creep-feeding favors these animals, since the calves are adapted early in life to solid diets, not counting the high weight the weaning.

However, some factors influence the response of supplementation. Such as: quantity and quality of forage that is offered, milk production of cows, the growth potential of the animal, age and sex of the calf and consumption of supplement (GOES et al., 2008).

2.3. Impact of supplementation in the suckling phase on the production and reproductive performance of beef cattle after weaning

Male calves that were supplemented during the rearing phase presented greater weaning weight. However, it is not clear if this additional weight will last during the productive cycle (MACHADO NETO et al., 2015).

Pacola et al., (1977) observed that there was a positive effect on the performance of confined animals when supplemented during the breeding phase, observed that most of the animals were weighed close to 430 kg.

In another study, Pacola et al., (1991) observed a positive effect on the supplementation of male calves when fed to the confinement soon after breeding, presenting 13.2 kg more than in the control treatment. A similar result was reported by Blanco et al., (2009) where animals that were supplemented and submitted to traditional weaning presented higher average daily gain when compared to animals weaned in normal time, but without addition of supplementation. Consequently, the time the animal took to reach slaughter weight was shorter.

Da Silva et al., (2017) working with Nelore heifers submitted to different levels of supplementation during the breeding and rearing phase observed greater gain for heifers supplemented with higher levels.

Another factor that influences the performance of animals after weaning is about the time the supplement was offered. Tarr et al., (1994) evaluated three different periods of supplementation (84, 56 or 28 days pre-weaning) and reported a higher gain for calves that were exposed for a longer time to supplementation.

For females the result is similar. Buskirk et al., (1996) and Tarr et al., (1994), provided supplementation for different days pre-weaning (0, 28, 56 or 84 days) and observed greater gain for heifers fed supplementation for a longer period of time.

Even supplementation with positive results regarding performance, reproductive performance and milk production of females submitted to supplementation in the lactation phase may be impaired.

Evaluating heifers that received supplementation in the breeding phase, Hixon et al. (1982) observed problems with milk production of heifers that were supplemented, even if their additional gain did not change. Possibly, heifers produced less milk due to the excess of adipose tissue that developed in the mammary gland.

Silva et al., (2017) observed that heifers supplemented with higher levels of supplementation had larger diameter follicles, which may be related to the development of these heifers was faster when compared with those who receive low level or absence of supplementation.

2.4. Milk production in beef cows

2.4.1. *Factors interfering in production*

Among all the factors that affect the milk production of beef cows, the environment, health and the genetic group are responsible for changing production. Being that the environmental factors are the ones that most interfere.

According to Brown et al. (2001), the main environmental factors influencing the milk production of beef cows are: the nutritional levels that cows undergo and the age at calving. However, there are other factors that also affect milk production cows, one of which is calf sex.

Richardson et al. (1997) observed that cows that fed male calves had a higher milk production. However, Alencar et al., (1988) and Fagundes et al., (2004), found no difference in milk production as to the sex of the calf.

Recently, Hess et al., (2016), working with dairy cows (Holstein Friesan and Jersey), found higher milk yield in cows whose first calving was female and second lactation production (for female calving at the first lactation) was greater than in the first lactating Jersey cows both as to Friesan Holstein cows.

Studies show that milk production is altered based on the nutritional levels in which the cows are submitted. Quadros & Lobato (1997), evaluating the milk production of pure and crossbred cows, submitted to two stocking rates, found that the production was lower for the cows of the highest stocking area (5.52 and 6.52 kg / day), respectively).

However, in another study, Fagundes et al. (2004) did not observe differences in milk production in crossbred cows, also submitted to different stocking rates (280 and 360 kg PV/ha).

The age of the animal influences the production of milk. Cobuci et al., (2001) evaluating lactation Guzerá cows, they observed that heifers showed milk production of less than more old cows, however, the persistency of lactation is most evident in heifers. In their study, Pimentel et al., (2006) evaluated 144 lactations, observed higher production in multiparous cows. This value reached 79% higher in relation to primiparous cows.

2.5. Nutritional requirements of beef cows and suckling calfs

2.5.1. Energy requirement of beef cows in lactation

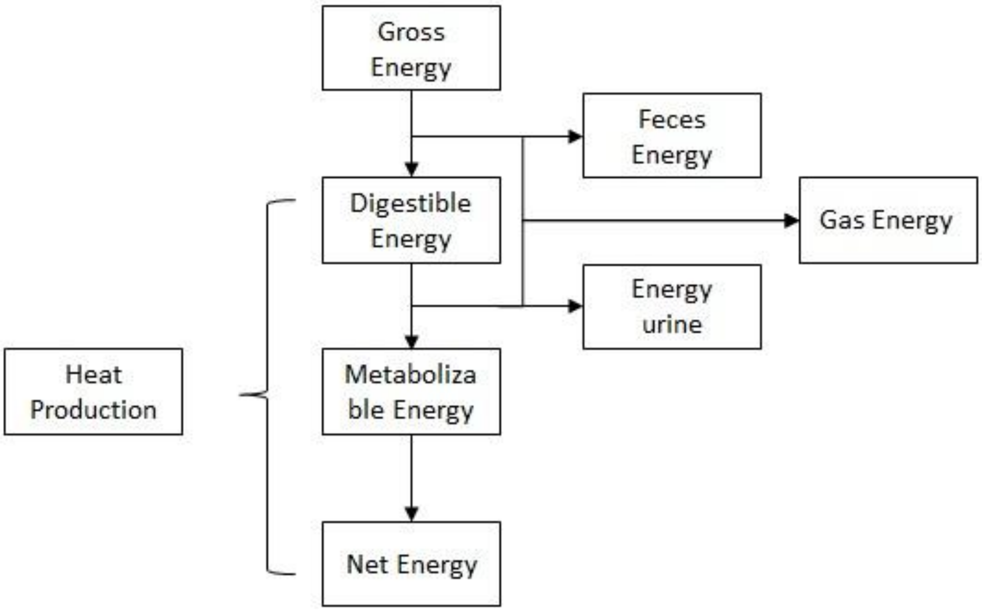
Lactating cows have a higher energy requirement when compared to non-lactating cows. Reynolds and Tyrell (2000), found in their study with crossbred heifers, requirement of keeping heifers lactating are 22 to 41% higher than non-lactating heifers, because at this stage, animals need energy to grow and produce milk.

The animal size also influences the requirement, since the greater the size of the cows, the more demanding they are, both during the dry period and during the lactation period, besides producing more demanding calves (FERREL & JENKINS, 1985).

However, carrying out work to estimate the nutritional requirement of lactating cows is not as simple. In addition to the intrinsic difficulties of the experiments to estimate the nutritional requirement of the animal, the involvement of lactating cows involves the measurement of the milk produced, so that the amount of energy that is "lost" to milk production can be found (VALADARES FILHO et al., 2010).

Energy is defined as the ability to perform work, and it can be measured during its transformation from one form to another. Energy is fundamental to the normal functioning of the body, including: breathing, circulation, physical activities, among others (Guimarães et al., 2012). However, ruminants are inefficient in the use of energy due to losses in the form of gases, heat, feces and urine, figure 5.

Figure 4: Schematic representation of the energy partition in ruminants



Source: Adapted Berchielli et al., 2011

The Gross Energy (GE) is that found in food. Its most common form of measurement is through a calorimetric pump (Berchielli et al., 2011). Then, if you have the Digestible Energy (DE), this is obtained when the energy lost in the feces is discounted. It is variable based on the chemical nature of the food (CALEGARE, 2004).

Some of the energy that has been absorbed by the animal is lost in the form of urine. When we subtract energy loss via DE urine, this balance is called Metabolizable Energy

(ME), which is the readily available energy from the metabolism of the animal, and on average, 82% of the digestible energy is metabolized (Berchielli et al., 2011).

Subsequently, ME can be used by the animal, known as Net Energy (NE) and represents part of the energy of the food that is retained in the animal in the form of any product, such as: meat, milk, wool and hair (Berchielli et al., 2011) and divided into two: Net energy for maintenance (NEm) and Net Energy for Gain (NEg).

The NRC system (2000) established that the NEm of 77 kcal/body weight$^{0.75}$ (BW), this result, obtained through the data of Lofgreen & Garret (1968). This system recommends a reduction of 10% for zebu animals and a 20% increase in lactating animals, that is, taking into account the values recommended by the NRC system (2000), NEm for lactating zebu cows would be 83 kcal/PC$^{0.75}$.

Working with growing cows, Paulino (2006) found NEm for this animal category equal to 79.35 kcal/empty body weight$^{0.75}$ (EBW). According to Valadares Filho et al. (2006), in the BR - Corte system, the recommendation of NEm for zebu of different classes is 78.5 kcal/EBW^{0,75}.

In their study with growing Nelore heifers, Gionbelli (2010) reported that the NEm for animals in this category would be 77.58 kcal/EBW$^{0.75}$. Results that corroborate that of Paulino (2006) and Valadares Filho et al., (2006).

When we consider the 20% increase, value proposed by the NRC (2000) system for lactating zebu cows, the estimated value for NEm is 94.2 kcal/EBW$^{0.75}$.

In primiparous cows, Fonseca et al., (2012) found that NEm is equal to 97.84 kcal/EBW$^{0.75}$, a result consistent with that found by Valadares Filho et al., (2006) adjusted to 20%, which was proposed by the NRC system (2000), both values correspond to 90 kcal/EBW$^{0.75}$.

However, few studies have been conducted to estimate the nutritional requirements of zebu lactating cows. In addition, these studies were carried out in confinement, where the animals are kept in stalls (to have greater control of the important variables) (VALADARES FILHO et al., 2016).

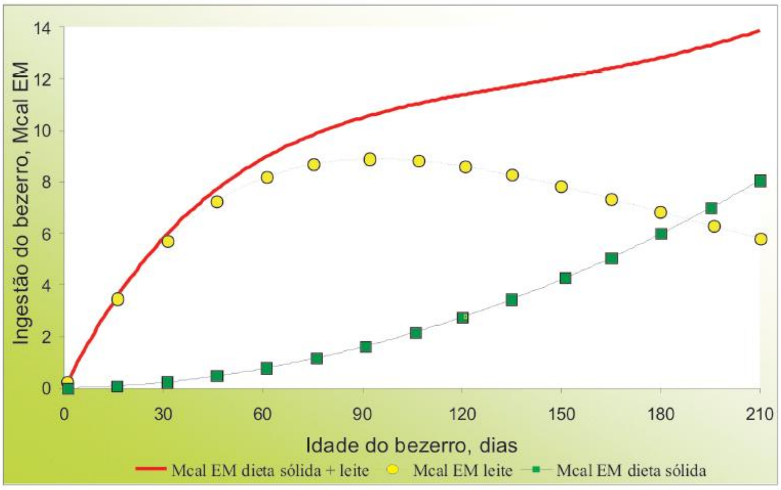
2.5.2. Energy requirement of beef calves

The development of the calf in the initial phase of postnatal life is related to the amount of milk ingested, since milk is the main food at this stage and its composition is compatible with the calf requirement (FONSECA et al., 2012).

At this stage the calf behaves physiologically as a non-ruminant, it does not have an active rumen. Therefore, this phase is very critical, because the animal presents some enzymatic limitations and absence of microbial synthesis, which makes some sources of energy and protein inefficient (FONSECA et al., 2012).

Up to 180 days of life, milk is the major energy contributor in the diet of calves and represents about 70% of the energy intake (ALBERTINI et al., 2009), according to figure 5.

Figure 5: Energy intake from the calf, from birth to weaning



Source: Albertini et al., 2007

Over time, milk intake by the calf falls over time and the energy source is gradually replaced by the solid diet.

However, substitution is associated with several problems, such as: inefficiency of enzymatic systems in the synthesis of enzymes capable of hydrolyzing carbohydrates other than lactose, other lipids other than milk, among others (Fonseca et al., 2012)

Therefore, it is extremely important to evaluate the nutritional requirement of suckling calves, thus helping to make decisions regarding the nutritional part, aiming for a higher productivity and a reduction in the slaughter age of these animals.

The best method to estimate the body composition involves the animal slaughtering and grinding of the carcass, for later laboratory analysis (Van Soest, 1994).

Estimating the body composition is fundamental to know the amount of energy present in the empty body of the animal, being adopted by several researchers the technique of comparative slaughter (GARRET, 1980).

Araujo et al. (1998) found NEm in crossbred animals, 71.76 kcal/kg$^{0.75}$, observed when the animals were 180 kg and 84.65 kcal/kg$^{0.75}$ were animals weighing 300 kg. In the Holstein calves, Signoretti et al., (1999)found higher than the average NEm reported by Araujo et al., (1998), 110.46 kcal/kg$^{0.75}$ vs 71.76 kcal/kg$^{0.75}$.

For Ferrel & Jenkins, (1998), variations in maintenance energy and gain efficiency are often associated with the weight and metabolic activity of visceral organs such as liver and gut.

The BR-Corte system (2016) shows that NEm for zebu calves weighing from 121 to 300 kg is 70.3 Kcal/$EBW^{0.75}$/day.

However, what matters in this phase is the gain of the animal, because at this stage is where it has the most accelerated development. For dairy calves, Carvalho et al., (2003) slaughtering animals with two different ages, 50 and 110 days post birth age, observed of 1.93 and 2.99 Mcal/EBWG.

For the BR-Corte system, 2016 NEg is given by the equation proposed by Fonseca et al. (2012). Where ELg is given by:

$$NE_g = 0{,}0932xEBW^{0,75}xEBWG^{0,75} \quad (1)$$

Where: NEg, net energy for gain; EBW, empty body weight; EBWG, empty body weight gain.

Few studies have been carried out to determine the requirement of beef calves, but it is worth noting that it is essential to know what the nutrient requirement for this animal category is due to the accelerated growth and development of the animals.

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SECOND CHAPTER

Manuscript: Long term effects of the use of creep-feeding for beef calves under tropical conditions

Article formatted in the Journal of Animal Science

ABSTRACT: The objectives of this study were to verify the systemic effects of the use of creep-feeding into beef cattle production system on weight variation of cows, the performance, intake and digestibility of calves during the suckling phase and alsothe residual effect in the post weaning phase. Thirty-six pairs of cows:calves [(year 1: 9 females and 9 males); (year 2: 14 females and 4 males), with initial weight of 550 ± 48 and 35 ± 5 kg, respectively, were used. The experimental design was completely randomized, factorial 2x2 (two treatments, control and *creep-feeding* and two calf sex, male and female). Experiment was divided into two phases: suckling (pre-weaning) phase and post-weaning phase. At pre-weaning phase, the animals were kept in an area of 6.2 hectares, divided into 20 paddocks (3,100 m2 each), composed of *Brachiaria decumbens*. The supplemented treatment calves received concentrated feed at the 0.7% level of BW daily. Milking of cows was performed monthly to estimate the milk intake of calves. Three behavioral trials were carried out along the suckling phase, evaluating the activities of grazing, idle, rumination, and suckling time. At post-suckling phase, the calves were separated by sex and both received supplementation during the evaluation periods (winter, spring and summer) until they achieved 18 months of age. The level of supplementation for winter/spring and summer was 0.5% and 0.3% of BW, respectively. Supplemented calves weaned heavier than control ($P < 0.001$). The same happened for sex, with male weaned heavier ($P<0.001$) and intake more milk than females ($P < 0.0001$). Supplementation reduced forage and milk intake of calves ($P<0.097$ and $P<0.001$, respectively) during the pre-weaning phase. Regarding to the behavior, supplemented animals spent less time grazing over time than control ($P<0.020$). At the post-weaning phase, animals that received c*reep-feeding* during the pre-weaning phase were heavier during winter ($P = 0.010$) and spring ($P = 0.080$) but not at the end of experiment (18 months) ($P = 0.291$). Males ate more forage than females during rearing periods ($P \leq 0.089$) gain more weightt ($P < 0.0001$). There was no effect on supplement intake at any phase of the experiment ($P \geq 0.172$); butt males gain more weight in all experiment phase ($P < 0.0001$). The use of *creep-feeding* increased the weight gain in the breeding phase, tends to be higher in males, males intakes more milk than females, but in the rearing, this gain tends to be partially lost.
Key words: beef cattle**,** *Bos taurus indicus*, milk production, supplementation

Introduction

Milk is the main source of nutrients for postpartum calves. As the animal grows, its daily requirement for nutrients increases dramatically as milk production of cows reduces. Thus, the use of supplements for these animals is very important, because allows better results in weight gain. In the breeding herd, calves response to supplementation are most evident, due to the accelerated growth of the animals in that phase and associated with the amount of ingested milk (GOES et al., 2008).

Many studies show positive effect on the performance of supplemented calves in the lactation phase (Ítavo et al., 2007; Moriel and Arthington, 2013; Gomes da Silva et al., 2017) and the positive effect of supplementation on the later phases (post weaning) (Azambuja et al., 2008; Almeida et al., 2015; Lazzarini et al., 2016)

However, research involving the use of creep-feeding in grazing of beef cattle production system has concentrated its efforts in specific situations of the production cycle, verifying, almost always, the effects on the calf only until weaning (Bailey et al., 1991; Neumann et al., 2005; Gomes da Silva et al., 2017).

It is unclear how supplementation affects milk production of cows (Gomes da Silva et al., 2017), but it is known that the animal eating solid feeds present “early” development of the ruminal epithelium, favoring the beginning of forage intake and reduction in frequency and intensity of suckling (Oliveira et al., 2007).

Based on this, we hypothesized that the effect of creep-feeding is systemic, with residual effects on the performance of the animal in later stages post weaning stages and also on the cows.

We also hypothesized that the calves’ supplementation with creep-feeding affects the milk production of cows and consequently their energetic state and also variations on body condition score (in a system with repeated use of creep-feeding in comparison to a system without the use of it).

Therefore, the objectives of this study were: to verify the effects of the use of creep-feeding into beef cattle production system on productive variables of cows, to verify residual effects of creep-feeding on animal performance in the post weaning phase.

Material and Methods

The study was conducted at the Beef Cattle facilities of the Department of Animal Science of the Universidade Federal de Lavras, in Lavras, Minas Gerais State, Brazil. The experiment was repeated over two years. The climatic data of the period are shown in the figure 1. All the experimental procedures were approved by the Ethics Committee on Animal Use – CEUA/UFLA (Protocol 024/17).

Animal, housing and feeding

Thirty-six pairs [Year 1 n = 18 (9 females and 9 male calves); Year 2 n = 18 (14 female and 4 male calves) of Tabapuã (*Bos taurus indicus*) cow:calf with initial average weight of 550 ± 48 kg and 35.6 ± 5.2 kg, respectively, were obtained from the UFLA herd. Before the experiment, cows were allowed to graze forage (*Brachiaria decumbens* Staf.) receiving a mineral and vitamins supplement. Animals were treated for internal and external parasites by the administration of ivermectin (Ivomec, Merial, Duluth, GA). In both years, the experiment was hold at the same areas. Every year of the experiment was divided into suckling phase and post weaning phase

Suckling phase. Before the experiment, cows were hand mated to 3 Tabapuã bulls (6-7 cows per bull) during a 70-d mating period. Thirty days before the estimated parturition, cows were moved to the calving paddock. After born, calves and their mother were weighed. The cow:calf pairs where then separated at random into two groups that received the feeding treatments. The groups were separated trying to achieve the same number of male and female calves in each treatment. During the suckling phase, the experiment was carried out in an area of 6.2 hectares, divided into 20 paddocks of 3,100 m^2 each. Animals were raised in an intermittent stocking system (Allen et al., 2011), animals enter a new paddock at 25 cm of sward height and leave it at 15 cm of sward eight (Pedreira et al., 2007). The forage available to the animals was *Brachiaria brizantha* (Table 1) fertilized with 40 kg per hectare per year of NPK (20 05 20), with two rest areas provided with creep trough system and concrete trough for cows mineral supplementation. Animals had permanent access to fresh water. At this stage, calves were not separated by gender.

When the cows reached 30 days postpartum, calves, along with their mothers, received mineral salt to condition the use of the private trough. At age 45 days the creep feeding system begin. The control group received only mineral supplementation in a similar structure, with an estimated consumption of 30 to 50 g / day for calves.

For the supplemented group, mineral salt was offered to cows and calves (equal to the control group), however, concentrate supplementation (Table 2) was offered to the calves in creep-feeding at 0.7% of their body weight per day. The suckling phase lasted 7 months (weaning will occured at 206 ± 22 d), similar than commercial beef cattle production systems (Oliveira et al., 2007).

Post-weaning phase.

After the period that includes the suckling phase, young bulls and heifers were raised under pasture until achieve 18 months of age and approximately 400 kg of BW (when they would be able to be finished in feedlots). The weaned calves were allocated to paddocks separated be gender (male and female), however, the animals not was separated by the treatment received in the suckling phase.

Animal was raised in an area containing *Brachiaria brizantha* (Table 1), of 5.8 ha each paddock under the continuous stocking system. In both years, the evaluation periods were divided in 3 steps:

The periods were:

- Winter
- Spring;
- Summer;

During the winter and spring, Table 2, was offered in a collective trough. The supply was adjusted based on the average weight of the group (0.5% of the average body weight of the group), for both genders.

During the summer, Table 2, was offered in a collective trough. The supply was adjusted based on the average weight of the group (0.3% of the average body weight of the group), for both genders.

Intake and digestibility trials

The dry matter intake and digestibility of calves' diets were evaluated using external markers. Three fecal collections (beginning, middle and end of the evaluation period) were performed throughout the suckling phase and three collections (a test every season) in the post-weaning phase (Figure 2).

The first collection was performed as soon as the animals enter the experimental period (45 days postpartum). The second collection was done in the middle phase of the experimental period (about 3.5 months after the beginning of the experiment) and the third collection, was in the final phase of the experiment (7 months after the beginning of the experimental phase).

In the post-weaning phase, the collections for digestibility was made once in each season of the year (Figure 2).

The fecals samples were of the spot type, performed in two different times, one done in the morning (6:00) and the other in the afternoon (18:00), in weaning and post-weaning phase.

For the estimation of forage intake, supplement intake and fecal production, three different types of indicators were used. For the estimation of fecal production, Titanium Dioxide (TiO_2) (Myers et al., 2004) will be calculated, using the equation:

$$FP\ (kg/dia) = \frac{CIFor}{CIFec} \tag{2}$$

Where, PF is fecal production, CIFor is the concentration of indicator supplied to the animal and CIFec is the concentration of indicator collected in the feces.

Forage intake was used the FDNi (Valente et al., 2011), calculated the consumption through the equation:

$$DMI_{forage}(kg/dia) = \frac{(FP\ x\ NDFi_{feces})}{NDFi\ forage} \tag{3}$$

Where, DMI_{forage} is the intake of dry matter of forage, FP is the fecal production (kg/day), $NDFi_{feces}$ is the concentration of NDFi in the feces (kg/kg), $NDFi_{forage}$ is the concentration of NDF in forage (kg/kg).

Chromium oxide (CrO_2) (Kimura et al., 1957) was used to supplement intake, the amount of supplement consumed will be found by the equation:

$$DMI_{supplement}(kg/day) = \frac{(FP \ x \ ICF)}{ICS} \quad (4)$$

Where $DMI_{supplement}$ is the dry matter intake of the supplement, FP is fecal production (kg/day), ICF is the indicator concentration in the feces and ICS is the indicator concentration in the supplement

Indicators were provided for 10 consecutive days. The CrO_2 was mixed in the supplement of the animals in a concentration of 0.5% of the supplement that was consumed, 10 g of TiO_2 per animal (cows and calves) was provided through the esophageal probe. The collection period was begin in the last four days of the indicators.

Chemical analyses

After collection, feces samples and forage samples, obtained by the hand-plucking method, were dried in a forced circulation oven at 55ºC, ground in a Wiley mill with a 2mm sieve for evaluation of iNDF and another portion of the sample will be milled in a 1 mm sieve, composed of animal by period.

The samples were analyzed for dry matter at 105ºC (DM; INCT-CA G-003/1), ethereal extract (EE; INCT-CA G-004/1), crude protein (CP; INCT-CA N-001/1), ash (INCT-

CA M-001/1), neutral detergent fiber (NDF; INCT-CA F-002/1) using thermostable α-amylase (Detmann et al., 2012) and quantification of indicators (Cr_2O, Kimura et al., 1957; TiO_2, Myers et al., 2004; FDNi, Valente et al., 2011).

Quality and milk production

At 14 days postpartum there was begin the measurements of production and quality of cows' milk, with one milking per month (totaling seven observations per cow/year).

The calves were separated from the mothers by 19:00 hours and milking was start 7:00 hours the next day (cows without contact with the calves for approximately 12 hours).

The milking was performed individually by portable mechanical milking machine and minutes before milking begins, 2 ml of Oxytocin (Ocitocina Forte UCB, Uzinas Chimicas Brasileiras S/A, Jaboticabal, Brasil) was applied in the abdominal subcutaneous vein ("milk vein"), so that there is total ejection of the milk. Milk production in 24 hours was calculated by the following of equation:

$$Calculated\ milk\ production\ (kg) = \left(\frac{Milk\ production\ (kg)}{(End\ of\ milking + 1) - Hour\ of\ isolation}\right) \quad (5)$$

After the milking end, the milk was weighed on a digital scale and subsequently volume measured with a beaker.

After measuring the volume, approximately 50 ml of the milk was sampled and sent to a commercial laboratory for analysis of fat, protein, lactose, solids, urea and casein.

Performance

For the calculation of performance over the experimental period, the animals was weighed monthly in the morning. The weights were noted to adjust the supplement supply to the animals. The average daily gain (ADG) was calculated, based on the following equation:

$$ADG = \frac{Final\,Weight - Initial\,Weight}{Number\ of\ days} \tag{6}$$

Cows were weighed at calving and every month until the weaning. Body condition score of the cows was evaluated at calving, at the beginning of the experiment (45 days postpartum) and the weaning.

Ingestive behaviour of beef calfs

There were two periods of evaluation of the behavior of the calves, separated in interval of six weeks. In each period, the animal behavior was observed for 48 hours uninterrupted, being monitored by human observation.

The activity that the animal is performing, frequency and time of feeding was recorded every 10 minutes, and the suckling time was recorded continuously. The observed behavior was the time that the animal spent grazing, ruminating, leisure, frequency and time of feeding.

Statistical analysis

The results was analyzed in SAS (SAS Inst. Inc., Cary, NC) using the MIXED procedure.

Food treatment (control or supplemented) and calf sex (male or female) was be treated as fixed effects and year as random.

The experimental design was the completely randomized, with a 2x2 factorial arrangement, being two feeding treatments (supplemented or not) and two gender of calves (male or female).

For the variables with repeated measurements use the repeated measures methodology was. Differences will be declared at $P<0.10$.

Results

Cow and calves performance during the suckling phase

Cow's BW at weaning and the ADG during the suckling phase (**Table 3**) were not affected by calves supplementation ($P = 0.691$ and $P = 0.864$ for BW and ADG, respectively) and sex ($P = 0.939$ and $P = 0.459$ for BW and ADG, respectively).

The creep-feeding increased the calf body weight at weaning (**Table 4**) ($P < 0.001$) and so creep-fed calves had greater ADG than control calves ($P < 0.001$). There was a trend between supplementation and sex effects on the weaning weight ($P = 0.103$) once the creep-feeding additional weight was of 36 kg in males and 13 kg in females. Male calves were heavier at weaning ($P < 0.001$) and gained more weight daily ($P = 0.001$) than the females.

Consumption, behavior and digestibility during suckling phase

No interactions between creep-feeding supplementation and calf sex were observed on intake, and feeding behavior variables ($P \geq 0.136$).

The creep-feeding supplementation increased absolute values (kg/d) of the DMI ($P = 0.038$) and also ($P = 0.068$) the intake in proportion of BW (g/kg) (**Table 5**). However, creep-fed calves had lower ($P = 0.097$) forage intake than the control group, even when the forage intake was expressed as proportion of BW (P = 0.028) of percentage of DMI (P < 0.001). The forage represented 77.8 % of the DMI of control calves and 60 % of DMI of creep-fed calves P < 0.001). In average, creep-fed calves ate 0.91 kg of supplement per day, that corresponds in average to 4.76 g/kg of BW during the suckling phase.

Despite the greater performance (**Table 5**), the male calves did not show more DMI than females (≥ 0.196). No effect of calf sex was also observed on forage (P ≥ 0.440) and supplement intake (P ≥ 0.376). However, males suckled more milk from their dams (P = 0.052; 5.54 versus 5.12 kg of milk per d for males and females, respectively).

Grazing time was affected by the treatment of the animals (**Table 6**), and animals in the control group spent more time grazing than the supplemented group (P = 0.060). Interactions were observed between age and variables such as grazing time and masticatory activity (**Figure 3 and 4**). For these variables, segmented models were adjusted to illustrate the activities over time. The critical age of deceleration of the increase in grazing time occurred eleven days earlier for supplemented animals in relation to the control group (98 vs. 109 days).

At the beginning, supplemented calves spent more time grazing than control calves, but in the second half of lactation the time of grazing is reversed, control animals spend more time grazing than supplemented calves, and with 210 days of calves supplemented spend 1 hour less grazing.

It was observed that the dry matter intake for supplemented animals (kg/day) was higher than the control group (P = 0.038) (**Table 7**), with no effect on the calf genotype (P = 0.394). With this, it was observed higher consumption of the other nutrients by the supplemented animals (P ≤ 0.054), however, no difference was observed in NDF intake (P = 0854).

In addition to having a higher dry matter intake per day (kg/day), supplemented animals consumed more dry matter per kgBW (g/kgBW) ($P = 0.068$), thus the consumption of other nutrients in the diet was higher for the group ($P \leq 0.084$), except for TDN and NDF ($P \geq 0.132$).

No difference was observed in the nutrient digestibility of calves ($P \geq 0.225$) (**Table 8**). However, animals in the control group had higher digestibility of NDF when compared to supplemented animals ($P = 0.009$).

Post-weaning phase performance

Calves that received supplementation in the offspring phase were the heaviest during the winter and spring period (**Table 9**), supplemented animals that were supplemented during breeding had 17 and 15 kg more than the control group in winter and spring respectively ($P \leq 0.080$). Regardless of the season of the year, male calves were heavier than female calves ($P < 0.001$) and during winter and summer presented higher weight gain in the period and average daily gain ($P < 0.001$). However, the same effect was not observed in the spring, males and females in this period presented even weight gain in the period and average daily gain ($P = 0.339$).

Figure 2 shows the performance of the animals throughout the experimental period.

Intake and digestibility in post-weaning phase

Regardless of the treatment offered in the suckling phase, there was no significant difference in dry matter intake and dietary components (forage and supplement) ($P \geq 0.126$) (**Table 10**). However, when evaluating the genus of calves, there is a difference in forage intake (kg / d) in all evaluation periods, with 14% more fodder in the winter than in females ($P \leq 0.089$).

Different from the suckling phase (**Table 11**) in the post-suckling phase, there was no effect of the treatment received in the previous phase on the nutrient intake of the diet ($P \geq 0.143$). However, in males, NDF consumption (kg / day) was higher than females in both spring and summer, 0.440 and 0.640 kg / d, respectively) ($P \leq 0.097$), similar to that observed in NFC consumption during the period of spring and summer ($P \leq 0.083$).

As the intake of NDF and NFC is higher for males, TND consumption is higher in males (1 kg / day more than females), but only in summer ($P = 0.022$).

Table 12 shows the digestibility data on the diet and the concentration of the total digestible nutrients. The treatments of the broiler phase had no influence on the nutrient digestibility of the diet ($P \geq 0.131$).

When the effect of sex is evaluated, there is a difference in protein digestibility during the summer. Females presented higher protein digestibility than males, 14% more ($P < 0.001$). Males had higher digestibility of NFC than females in the spring, the difference between males and females of 66 g / kg ($P = 0.057$). In the summer there was difference in TDN digestibility, the digestibility was 3.3% higher for males ($P = 0.014$).

Discussion

The results observed were similar to those found by Newman et al. (2005), where male calves that received supplementation had higher weaning weight and higher ADG than females who also received supplementation (0.785 vs 0.666 kg / day). This result was already expect, since males show more accelerated growth than females (VITTORI et al., 2006).

Males have the advantage that their mothers produce more milk (Oliveira et al., 2016). According to Albertini et al., 2007, until the 180 days of calf life, milk is the largest corresponding in the diet of the calves, representing 70% of the energy ingested by the animals.

Working with buffalo Oliveira et al., 2016, observed that males spent more time and sought their mothers more frequently when compared to females, having a positive result in mothers' milk production.

According to the BR-Corte system (2010), the energy expenditure is 1.07 Mcal / kg of milk produced. With the use of the supplementation it was observed a reduction in the milk production of the cows, therefore, the energy that would be spent for the milk production of the cows may have been destined for reproduction, for example.

Supplementation for calves may influence the milk production of cows. . In this study, a reduction of 12.5% in milk yield of cows fed supplemented calves (4.98 vs. 5.69 liters, supplemented or not, respectively) was observed. This is because part of the nutritional requirement of calves is being supplied by the concentrated feed, thus the cow's milk production decreases. In the meantime, some studies have found no effect of supplementation on milk production of cows (BARROS et al., 2014; LIMA et al., 2016; SILVA et al., 2016; LOPES et al., 2016).

Porto et al., 2009, working with different sources of energy in supplements for calves, found differences in milk production of cows, calves receiving supplementation are less dependent on mothers, and thus consume less milk.

When supplementation is used in the diet of grazing cattle, it is necessary to think that there are associative effects between supplement and pasture, and this may affect forage consumption (PAULINO et al., 2004).

Among the associative effects (additive, substitute and combined), the ideal is the additive effect of supplementation, that is, supplementation comes as additional in the energy consumption of the diet (MOORE, 1980), in contrast, the substitute effect of supplementation, or be it, the animal reduces the intake of pasture dry matter and increases supplement consumption is not ideal.

In this study, it was observed that calves from the control group presented higher pasture dry matter intake when compared to supplemented calves (77.84 vs 60.03 kg/d), showing a clear effect of replacing the pasture with the supplement, however, some studies have not reported difference on forage consumption when the animal receives grazing supplementation (BARROS et al., 2014; LIMA et al., 2016).

The ingestive behavior of calves also changes with the use of supplementation. In this study, there was difference in grazing time between control and supplemented animals. Calves receiving supplementation spent less grazing time, in the second half of lactation, showing that there is a substitutive effect of supplementation.

Another point is that calf receiving supplementation has reduced masticatory activity because the consumption of forage is replaced by that of supplement

Intake and digestibility of forage dry matter are essential attributes that determine the production of grazing animal (BERCHIELLI et al., 2011). Since some factors interfere both in the intake (animal, age, food) and in the digestibility of the food (particle size, fiber quality). (REIS et al., 2013).

Animals whose diet has concentrated foods have a higher rate of passage when compared to animals that receive only bulky. This is because food bulk has higher fiber content, making their stay in the rumen larger, so that better use of the fiber occurs. (BERCHIELLI, et al. 2011)

For the degradation of the fibers by the fibrolytic bacteria in the rumen, it is necessary that the nitrogen requirement of the rumen is met for adequate fiber utilization, according to the work of Lazzarini et al., 2009, the nitrogen requirement of the rumen is 7-8%. In this case, where the crude protein content of the forage was around 7.8%, indicating that only the protein of the forage was enough to supply the rumen requirements to the point of not harming, but to favor the digestibility of the fiber.

As reported by Angell et al., 1995, the use of supplementation observed that the use of supplementation reduced the digest residence time in the rumen and increasing the digestion rate.

In their study with Nellore cattle receiving different levels of protein supplementation, Oliveira et al., 2010 observed that the control group presented a lower rate of passage when compared to animals receiving supplementation and observed an increase in rumen digest time.

Throughout the experimental period, male calves presented higher body weight. During the winter and spring period, the animals that were supplemented presented higher body weight when compared to the calves of the control group, showing that there is still a residual effect of supplementation in this phase.

Regardless of the period, males presented higher forage consumption. The nutritional requirement of males and females is different, if two animals of the same age, but of different sex, or even of different categories (e.g. pregnant and lactating females) are compared, their nutritional requirements will not be the same (Valadares Filho et al., 2016).

However, over time the additional gain in the suckling phase has been decreasing over time. The difference in weight of the animals that did not receive supplementation for those who received was 25 kg (215 vs 240 kg, respectively) in the suckling phase. At the end of the experimental period, this difference reached 13 kg (377 vs 390 kg, respectively), a 48%

reduction in the weight difference of the animals. This loss of performance is associated with a reduction in the levels of supplementation that was offered to the animals during the post-weaning phase (0.7g/kg BW in weaning phase, 0.5g/kg BW in winter/spring and 0.3g/kg BW in summer).

Conclusions

The use of supplement in the weaning phase improves the performance of the animals being that males tend to gain more weight than females. Changes in milk consumption of animals, supplemented calves suck less, but males, intake more milk than females, regardless of the treatment.

The supplementation in the weaning phase reduces forage intake by altering the ingestive behavior of the calves. After weaning, the additive effect of supplementation in the weaning phase tended to decrease in the later stages, the difference remained for the first two periods of the rearing, but in the last this gain was lost.

Background

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Table 1: Chemical composition of the forage used in this experiment

Item	Suckling phase	Winter	Spring	Summer
MM, %	7.80	13.52	14.36	13.75
OM, %	91.82	92.94	92.13	91.90
CP, %	7.34	10.21	11.27	9.51
EE, %	1.96	1.55	1.89	1.64
NDF, %	67.46	61.65	65.50	68.43
NFC, %	14.93	16.69	10.06	9.63
iNDF, %	16.42	17.57	17.58	17.52

*MM = mineral matter; OM = organic matter; CP = crude protein; EE = ethereal extract; NDF – neutral detergent fiber; NFC = non-fibrous carbohydrates; iNDF = indigestible neutral detergent fiber

Table 2: Chemical composition of the supplement used in the experiment

Item	Creep-feeding	Winter	Spring	Summer
MM, %	8.18	7.06	7.87	8.10
OM, %	91.4	86.5	85.6	86.2
CP, %	24.2	33.8	21.9	23.0
EE, %	4.4	4.3	4.6	5.1
NDF, %	28.8	28.2	24.0	25.5
NFC, %	36.4	20.1	35.2	32.7

*MM = mineral matter; OM = organic matter; CP = crude protein; EE = ethereal extract;
NDF – neutral detergent fiber; NFC = non-fibrous carbohydrates; NFC = non-fibrous carbohydates

Table 3: Performance of lactating cows supplemented or not during the suckling phase under tropical conditions

Item	Control		Creep-fed		P - value		
	Male	Female	Male	Female	Suplementation	Sex	Suplementation x Sex
Initial							
Cow BW at birth, kg	597 ± 21.45	588 ± 18.57	577 ± 21.45	581 ± 15.84	0.487	0.899	0.718
Cow BW, kg	593 ± 20.72	588 ± 17.94	572 ± 20.72	574 ± 15.30	0.354	0.837	0.930
Weaning							
Cow BW, kg	558 ± 16,09	552 ± 14,81	546 ± 26,40	550 ± 14.54	0.691	0.939	0.773
Cow ADG, kg/d	-0.02 ± 0.05	-0.10 ± 0.06	-0.04 ± 0.06	-0.06 ± 0.04	0.864	0.459	0.598

*BW = body weight; ADG = average daily gain

Table 4: Performance of calves supplemented or not supplemented via creep-feeding during suckling phase under tropical conditions

Item	Creep-feeding		Sex		P-value		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
Calf BW at birth, kg	35.2 ± 1.5	36.9 ± 1.63	36.0 ± 1.63	36.0 ± 1.55	0.470	0.974	0.126
Age at weaning, d	207 ± 11	208 ± 11	202 ± 10.39	213 ± 10.93	0.865	0.156	0.187
BW210 days, kg	215 ± 5.0	240 ± 5.0	216 ± 4.42	238 ± 5.50	<0.001	<0.001	0.103
Female	210 ± 6.56	223 ± 5.93	.	.	.	.	.
Male	220 ± 7.43	256 ± 8.03	.	.	.	.	.
Total BW gaing, kg	180 ± 5.00	202 ± 5.04	181 ± 4.47	201 ± 5.53	<0.001	<0.001	0.322
Female	174 ± 6.26	189 ± 6.00	.	.	.	.	.
Male	186 ± 7,51	216 ± 8.11	.	.	.	.	.
ADG, kg/d	0.85 ± 0.02	0.96 ± 0.02	0.86 ± 0.02	0.95 ± 0.02	<0.001	<0.001	0.312
Female	0.82 ± 0.03	0.90 ± 0.03	.	.	.	.	.
Male	0.88 ± 0.03	1.02 ± 0.03	.	.	.	.	.

*BW = body weight; ADG = average daily gain; CF = creep-feeding; BW 210 = adjusted weight at day 210 of age. Equivalent to weaning weight

Table 5: Dry matter intake, forage, milk and supplement intake of creep-fed animals during the suckling phases under tropical conditions.

Item	Creep-feeding		Sex		P-Value		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
			Forage				
DMI							
kg/d	2.92 ± 0.39	2.57 ± 0.40	2.66 ± 0.39	2.83 ± 0.41	0.097	0.440	0.742
g/kgBW	16.3 ± .02	14.1 ± 2.05	15.6 ± 2.01	14.8 ± 2.08	0.028	0.489	0.377
% intake	77.8 ± 4.00	60.0 ± 4.09	68.4 ± 3.96	69.4 ± 4.16	<0.001	0.703	0.602
			Supplement				
DMI							
kg/d	-	-	0.89 ± 0.17	0.92 ± 0.19	-	0.846	-
g/kgBW	-	-	5.08 ± 0.74	4.41 ± 0.86	-	0.376	-
% intake	-	-	22.44 ± 4.27	21.90 ± 4.74		0.877	
			Milk				
Intake, kg	5.69 ± 0.40	4.98 ± 0.41	5.12 ± 0.40	5.54 ± 0.41	<0.001	0.052	0.328
DMI							
kg/d	0.72 ± 0.04	0.64 ± 0.04	0.65 ± 0.04	0.70 ± 0.05	0.008	0.103	0.787
g/kgBW	4.37 ± 0.68	3.72 ± 0.68	4.08 ± 0.68	4.02 ± 0.69	0.004	0.798	0.210
% intake	21.7 ± 3.10	17.3 ± 3.11	19.0 ± 3.10	20.0 ± 3.13	<0.001	0.405	0.937

* CF = creep-feeding

Table 6: Ingestive behavior of supplemented calves during suckling phase under tropical conditions

Item	Creep-feeding		Sex		P-values						
	Control	Supplemented	Female	Male	AGE	CF	SEX	AGE×CF	AGE×SEX	CF×SEX	AGE×CF×SEX
Grazing, min/d	192±23	178±23	182±24	187±22	<0.001	0.060	0.581	0.020	0.603	0.580	0.694
Ruminating, min/d	160±8	147±9	147±7	160±9	0.014	0.406	0.943	0.594	0.654	0.097	0.119
Total chewing, min/d	373±28	344±30	351±30	366±28	<0.001	0.642	0.825	0.356	0.999	0.448	0.451
Idle, min/d	805±27	843±29	840±29	807±28	<0.001	0.692	0.512	0.332	0.804	0.787	0.833
Other, min/d	276±14	272±14	270±15	278±14	<0.001	0.957	0.471	0.904	0.687	0.672	0.576
Suckling frequency	4.62±0.3	4.52±0.3	3.93±0.3	5.20±0.3	<0.001	0.227	0.004	0.080	0.130	0.110	0.102
Suckling duration, min	6.50±0.2	6.54±0.2	6.53±0.2	6.50±0.3	0.721	0.951	0.660	0.900	0.636	0.462	0.381
Total suckled, min/d	29.2±1.8	28.6±1.9	24.7±1.6	33.0±2.1	0.008	0.509	0.061	0.333	0.425	0.397	0.463

* CF = creep-feeding

Table 7: Nutrient fractions and total digestible nutrients intake of creep-fed animals during the suckling phase under tropical conditions.

Item	Creep-feeding		Sex		P-values		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
DMI							
kg/d	3.66 ± 0.37	4.13 ± 0.38	3.80 ± 0.37	4.00 ± 0.39	0.038	0.394	0.587
g/kgBW	20.8 ± 1.96	22.8 ± 1.99	22.5 ± 1.94	21,1 ± 2.02	0.068	0.196	0.190
OMI							
kg/d	3.4 ± 0.34	3.83 ± 0.35	3.52 ± 0.34	3.72 ± 0.35	0.046	0.368	0.553
g/kgBW	19.5 ± 1.83	21.1 ± 1.87	20.9 ± 1.82	19.6 ± 1.89	0.084	0.203	0.200
CPI							
kg/d	0.42 ± 0.03	0.58 ± 0.03	0.49 ± 0.03	0.50 ± 0.03	<0.01	0.678	0.756
g/kgBW	2.47 ± 0.24	3.27 ± 0.22	3.00 ± 0.21	2.74 ± 0.22	<0.01	0.066	0.086
Male	2.45c	3.03b	-	-			
Female	2.48c	3.51a	-	-			
NDFI							
kg/d	1.97 ± 0.22	1.94 ± 0.23	1.89 ± 0.22	2.01 ± 0.23	0.854	0.385	0.623
g/kgBW	11.0 ± 1.15	10.6 ± 1.17	11.1 ± 1.14	10.5 ± 1.19	0.522	0.401	0.344
NFCI							
kg/d	0.72 ± 0.10	0.98±0.10	0.83±0.10	0.87±0.10	<0.01	0.443	0.384
g/kgBW	4.16 ± 0.60	5.42±0.61	4.94±0.60	4.63±0.61	<0.01	0.236	0.399
TDNI							
kg/d	2.79 ± 0.25	3.10 ± 0.25	2.88 ± 0.24	3.02 ± 0.25	0.054	0.408	0.655
q/kgBW	16.1 ± 1.60	17.3 ± 1.62	17.3 ± 1.59	16.1 ± 1.64	0.132	0.156	0.136

* CF = creep-feeding; DMI = dry matter intake; OMI = organic dry matter intake; CPI = crude protein intake; NDFI = neutral detergent fiber intake; NFCI = non-fibrous carbohydrates intake; TDNI = total digestible nutrient intake

Table 8: Nutrient digestibility of calves supplemented or not under tropical conditions

Item	Creep-feeding		Sex		P-value		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
DM, g/kg	711 ± 16.92	709 ± 17.08	711 ± 16.76	708 ± 17.33	0.775	0.662	0.320
OM, g/kg	747 ± 16.02	743 ± 16.19	747 ± 15.86	743 ± 16.43	0.609	0.606	0.241
CP, g/kg	716 ± 20.13	703 ± 20.60	712 ± 19.61	707 ± 21.33	0.435	0.798	0.165
NDF, g/kg	671 ± 22.64	641 ± 22.82	661 ± 22.49	651 ± 23.10	0.009	0.444	0.393
NFC, g/kg	925 ± 12.50	919 ± 12.73	916 ± 12.27	928 ± 13.10	0.501	0.225	0.529
TDN, g/kg	769 ± 26.28	756 ± 26.48	765 ± 26.10	760 ± 26.76	0285	0710	0618

* CF = creep-feeding; DM = dry matter; OM = organic dry matter; CP = crude protein; NDF = neutral detergent fiber; NFC = non-fibrous carbohydrates; TDN = total digestible nutrient

Table 9:Performance of creep-fed animals during the post-weaning phases (winter, spring and summer) under tropical conditions.

Item	Creep-feeding		Sex		P-value		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
Winter							
BW11 months, kg	260 ± 5.92	277 ± 5.93	247 ± 5.55	290 ± 6.35	0.010	<0.001	0.142
Female	243 ± 7.10	251 ± 6.65	.	.	.	.	.
Male	276 ± 7.87	303 ± 8.32	.	.	.	.	.
BWG period, kg	44.8 ± 6.50	37.6 ± 6.51	31.1 ± 6.23	51.3 ± 6.85	0.231	<0.001	0.720
Female	33.6 ± 7.42	28.5 ± 7.07	.	.	.	.	.
Male	55.9 ± 8.05	46.6 ± 8.41	.	.	.	.	.
ADG, kg/d	0.37 ± 0.05	0.31 ± 0.05	0.25 ± 0.05	0.42 ± 0.05	0.232	<0.001	0.719
Female	0.28 ± 0.06	0.23 ± 0.05	.	.	.	.	.
Male	0.46 ± 0.06	0.38 ± 0.07	.	.	.	.	.
Spring							
BW13 months, kg	296 ± 7.84	311 ± 7.86	280 ± 7.37	327 ± 8.41	0.080	<0.001	0.321
Female	277 ± 9.42	284 ± 8.82	.	.	.	.	.
Male	315 ± 10.43	339 ± 11.03	.	.	.	.	.
BWG period, kg	36.4 ± 3.29	34.1 ± 3.31	33.0 ± 2.93	37.5 ± 3.63	0.620	0.339	0.820
Female	33.6 ± 4.35	32.4 ± 3.94	.	.	.	.	.
Male	39.2 ± 4.94	35.8 ± 5.33	.	.	.	.	.
ADG, kg/d	0.60 ± 0.05	0.56 ± 0.05	0.55 ± 0.5	0.62 ± 0.06	0.621	0.339	0.820
Female	0.56 ± 0.07	0.54 ± 0.06	.	.	.	.	.
Male	0.65 ± 0.08	0.59 ± 0.09	.	.	.	.	.
Summer							
BW18 months, kg	377 ± 18.06	390 ± 17.94	347 ± 17.61	420 ± 18.5	0.291	<0.001	0.674
Female	343 ± 19.83	351 ± 18.86	.	.	.	.	.
Male	410 ± 20.51	429 ± 21.13	.	.	.	.	.
BWG period, kg	81.5 ± 24.08	78.8 ± 24.03	65.7 ± 23.92	94.7 ± 24.24	0.758	<0.001	0.742
Female	65.6 ± 24.73	65.8 ± 24.37	.	.	.	.	.
Male	97.5 ± 25.00	91.9 ± 25.24	.	.	.	.	.
ADG, kg	0.53 ± 0.10	0.54 ± 0.10	0.47 ± 0.10	0.61 ± 0.10	0.859	<0.001	0.157
Female	0.43 ± 0.10	0.50 ± 0.10	.	.	.	.	.
Male	0.64 ± 0.10	0.58 ± 0.10	.	.	.	.	.

CF = creep-feeding; BW 11 = body weight at 11 months; BW 13 = body weight at 13 months; BW 18 = body weight at 18 months

Table 10: Dry matter intake, forage and supplement intake of creep-fed animals during the post-weaning phases (winter, spring and summer) under tropical conditions.

Item	Creep-feeding		Sex		P-values		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
Dry matter intake, kg/d							
Winter	4.81±0.47	4.72±0.47	4.46±0.43	5.07±0.50	0.824	0.152	0.479
Spring	6.45±0.32	6.60±0.36	6.24±0.27	6.82±0.40	0.761	0.257	0.792
Summer	7.24±0.81	7.62±0.81	6.83±0.79	8.03±0.83	0.472	0.043	0.358
Dry matter intake, g/kg/BW							
Winter	19.21±1.19	16.9±1.19	18.1±0.90	18.03±1.43	0.212	0.954	0.381
Spring	23.8±1.08	22.06±1.20	24.03±1.00	21.93±1.30	0.198	0.156	0.258
Summer	20.4±2.25	19.76±2.52	20.8±2.47	19.3±2.58	0.636	0.331	0.474
Forage intake, kg/d							
Winter	3.42±0.46	3.41±0.46	3.15±0.44	3.68±0.48	0.969	0.089	0.808
Spring	5.53±0.22	5.73±0.25	5.30±0.19	5.96±0.28	0.575	0.080	0.775
Summer	6.20±0.68	6.58±0.68	5.97±0.66	6.81±0.69	0.342	0.054	0.224
Forage intake, g/kg/BW							
Winter	13.61±1.17	12.3±1.17	12.9±0.98	13.0±1.34	0.413	0.988	0.771
Spring	20.5±0.78	18.9±0.90	20.6±0.68	18.8±0.98	0.212	0.169	0.536
Summer	17.6±2.16	17.0±2.16	18.3±2.12	16.3±2.21	0.666	0.155	0.416
% Intake							
Winter	0.70±0.05	0.72±0.05	0.71±0.05	0.72±0.05	0.531	0.811	0.422
Spring	0.86±0.01	0.86±0.22	0.85±0.01	0.87±0.02	0.894	0.582	0.334
Summer	0.86±0.01	0.86±0.01	0.87±0.01	0.84±0.01	0.977	0.219	0.750
Supplement intake, kg/d							
Winter	1.37±0.21	1.29±0.21	1.27±0.19	1.39±0.23	0.703	0.589	0.298
Spring	0.92±0.18	0.90±0.20	0.92±0.16	0.90±0.22	0.921	0.941	0.401
Summer	1.02±0.16	1.03±0.16	0.86±0.14	1.19±0.18	0.973	0.172	0.976

Supplement intake, g/kg/BW							
Winter	5.64±1.00	4.60±1.00	5.22±0.96	5.01±1.04	0.126	0.743	0.100
Spring	3.36±0.61	3.05±0.68	3.47±0.56	2.94±0.74	0.686	0.523	0.264
Summer	2.83±0.45	2.66±0.45	2.60±0.39	2.88±0.50	0.786	0.653	0.939
% Intake							
Winter	0.29±0.05	0.27±0.05	0.28±0.05	0.27±0.05	0.531	0.811	0.422
Spring	0.13±0.01	0.13±0.02	0.14±0.01	0.12±0.02	0.894	0.582	0.334
Summer	0.13±0.01	0.13±0.01	0.12±0.01	0.15±0.01	0.977	0.219	0.750

*CF = creep-feeding

Table 11: Nutrient fractions and total digestible nutrients intake of creep-fed animals during the post-weaning phases (winter, spring and summer) under tropical conditions.

Item	Creep-feeding		Sex		P-values		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
Organic matter intake, kg/d							
Winter	4.38±0.43	4.30±0.43	4.05±0.40	4.62±0.46	0.830	0.145	0.491
Spring	5.88±0.28	6.04±0.32	5.68±0.24	6.25±0.35	0.723	0.211	0.837
Summer	6.60±0.73	6.95±0.73	6.20±0.71	7.34±0.75	0.459	0.033	0.346
Organic matter intake, g/kg/BW							
Winter	17.4±1.09	15.4±1.09	16.5±0.82	16.4±1.30	0.218	0.955	0.397
Spring	21.7±0.79	20.0±0.91	21.9±0.69	19.0±0.99	0.175	0.102	0.242
Summer	18.6±2.25	18.0±2.25	18.9±2.21	17.6±2.31	0.632	0.357	0.459
Crude protein intake, kg/d							
Winter	0.75±0.05	0.72±0.05	0.69±0.04	0.78±0.06	0.726	0.290	0.318
Spring	0.80±0.05	0.82±0.05	0.84±0.04	0.78±0.06	0.885	0.387	0.599
Summer	0.76±0.13	0.88±0.13	0.77±0.13	0.87±0.14	0.311	0.430	0.788
Crude protein intake, g/kg/BW							
Winter	3.05±0.28	2.60±0.28	2.60±0.28	2.80±0.31	0.143	0.858	0.176
Spring	3.00±0.16	2.78±0.17	3.25±0.15	2.53±0.19	0.264	0.004	0.214
Summer	2.19±0.39	2.29±0.39	2.37±0.38	2.10±0.40	0.728	0.358	0.774

NDF intake, kg/d							
Winter	2.78±0.28	2.75±0.28	2.56±0.26	2.96±0.29	0.894	0.105	0.626
Spring	3.83±0.16	4.01±0.18	3.70±0.13	4.14±0.20	0.481	0.097	0.783
Summer	4.37±0.40	4.63±0.40	4.18±0.39	4.82±0.41	0.352	0.040	0.244
NDF intake, g/kg/BW							
Winter	11.1±0.74	9.96±0.74	10.5±0.56	10.5±0.89	0.303	0.960	0.573
Spring	14.2±0.48	13.2±0.55	14.3±0.41	13.0±0.60	0.224	0.114	0.470
Summer	12.3±1.24	12.0±1.24	12.8±1.21	11.5±1.28	0.647	0.156	0.373
NFC intake, kg/d							
Winter	0.62±0.03	0.61±0.03	0.58±0.02	0.65±0.04	0.759	0.198	0.361
Spring	0.91±0.07	0.87±0.09	0.78±0.06	1.01±0.09	0.741	0.083	0.371
Summer	1.13±0.16	1.08±0.16	0.95±0.15	1.26±0.17	0.777	0.050	0.358
NFC intake, g/kg/BW							
Winter	2.51±0.16	2.18±0.16	2.35±0.12	2.34±0.19	0.174	0.953	0.264
Spring	3.34±0.26	2.88±0.29	2.99±0.22	3.23±0.32	0.264	0.567	0.160
Summer	3.15±0.53	2.82±0.53	2.90±0.51	3.07±0.55	0.402	0.671	0.450
TDN intake, kg/d							
Winter	2.66±0.25	2.62±0.25	2.49±0.22	2.79±0.27	0.873	0.257	0.247
Spring	3.81±0.19	3.98±0.21	3.72±0.16	4.07±0.23	0.565	0.261	0.743
Summer	4.17±0.65	4.36±0.65	3.76±0.64	4.76±0.66	0.612	0.022	0.353
TDN intake, g/kg/BW							
Winter	10.65±0.76	9.42±0.76	10.2±0.57	9.87±0.91	0.279	0.762	0.212
Spring	14.1±0.59	13.2±0.67	14.4±0.51	12.9±0.73	0.345	0.119	0.229
Summer	11.7±2.00	11.2±2.00	11.5±1.96	11.5±2.04	0.683	0.969	0.479

*CF = creep-feeding; NDF = neutral detergent fiber; NFC = non-fibrous carbohydrates; TDN = total digestible nutrients

Table 12: Digestibility and concentration of total digestible nutrients of creep-fed animals during the post-weaning phases (winter, spring and summer) under tropical conditions.

Item	Creep-feeding		Sex		P-values		
	Control	Supplemented	Female	Male	CF	SEX	CF×SEX
Dry matter digestibility, g/kg							
Winter	528±14.4	517±14.4	523±14.3	522±14.6	0.131	0.811	-
Spring	558±5.59	566±5.24	559±5.24	565±6.28	0.361	0.403	0.747
Summer	557±14.2	561±14.2	553±14.2	565±14.4	0.679	0.180	0.306
Organic matter digestibility, g/kg							
Winter	562±8.56	553±8.29	561±8.15	554±8.82	0.194	0.373	0.799
Spring	595±5.24	603±5.61	597±4.89	601±5.92	0.271	0.561	0.496
Summer	596±18.0	599±17.9	591±17.9	603±18.1	0.675	0.178	0.232
Crude protein digestibility, g/kg							
Winter	709±9.06	691±8.23	702±7.16	697±9.92	0.152	0.698	0.535
Spring	626±20.6	643±20.9	683±20.3	587±21.3	0.247	<0.001	0.360
Summer	540±68.3	610±67.8	607±67.4	543±70.4	0.281	0.360	0.321
NDF digestibility, g/kg							
Winter	494±34.5	486±34.4	500±34.3	479±34.7	0.515	0.126	0.663
Spring	546±10.2	547±10.8	545±9.79	548±11.3	0.902	0.801	0.700
Summer	553±12.3	560±12.3	551±12.2	562±12.7	0.550	0.355	0.456
NFC digestibility, g/kg							
Winter	639±70.4	648±69.8	621±69.6	666±71.0	0.804	0.222	0.030
Spring	759±22.6	799±24.2	746±21.1	812±25.5	0.228	0.057	0.258
Summer	774±35.2	741±34.9	768±34.2	746±36.7	0.436	0.626	0.317
Total digestible nutrients, g/kg							
Winter	569±5.39	559±4.90	568±4.29	560±5.89	0.176	0.331	0.927
Spring	588±7.84	597±8.06	598±7.68	587±8.34	0.236	0.152	0.599
Summer	579±16.5	585±16.5	572±16.5	592±16.6	0.395	0.014	0.412

*CF = creep-feeding

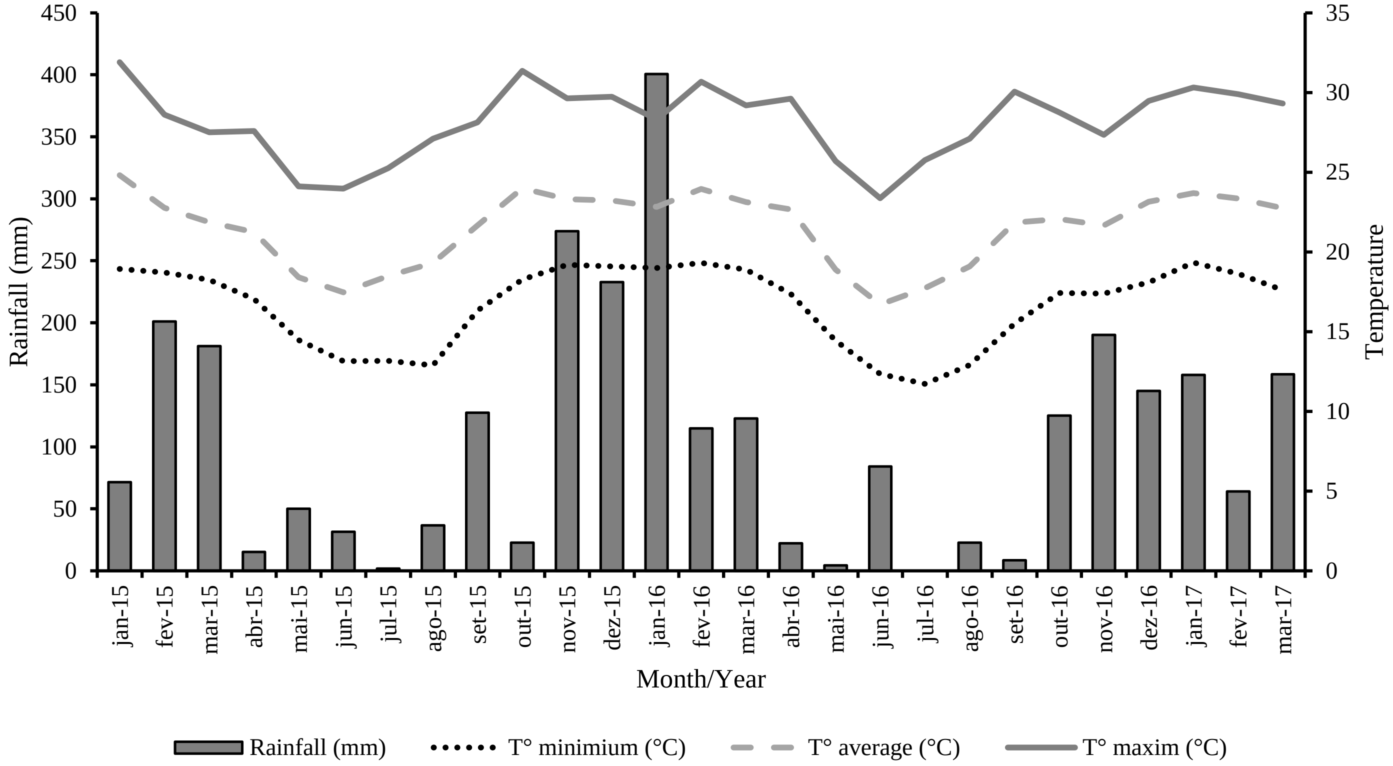

Figure 1: Climatic data during the experimental period

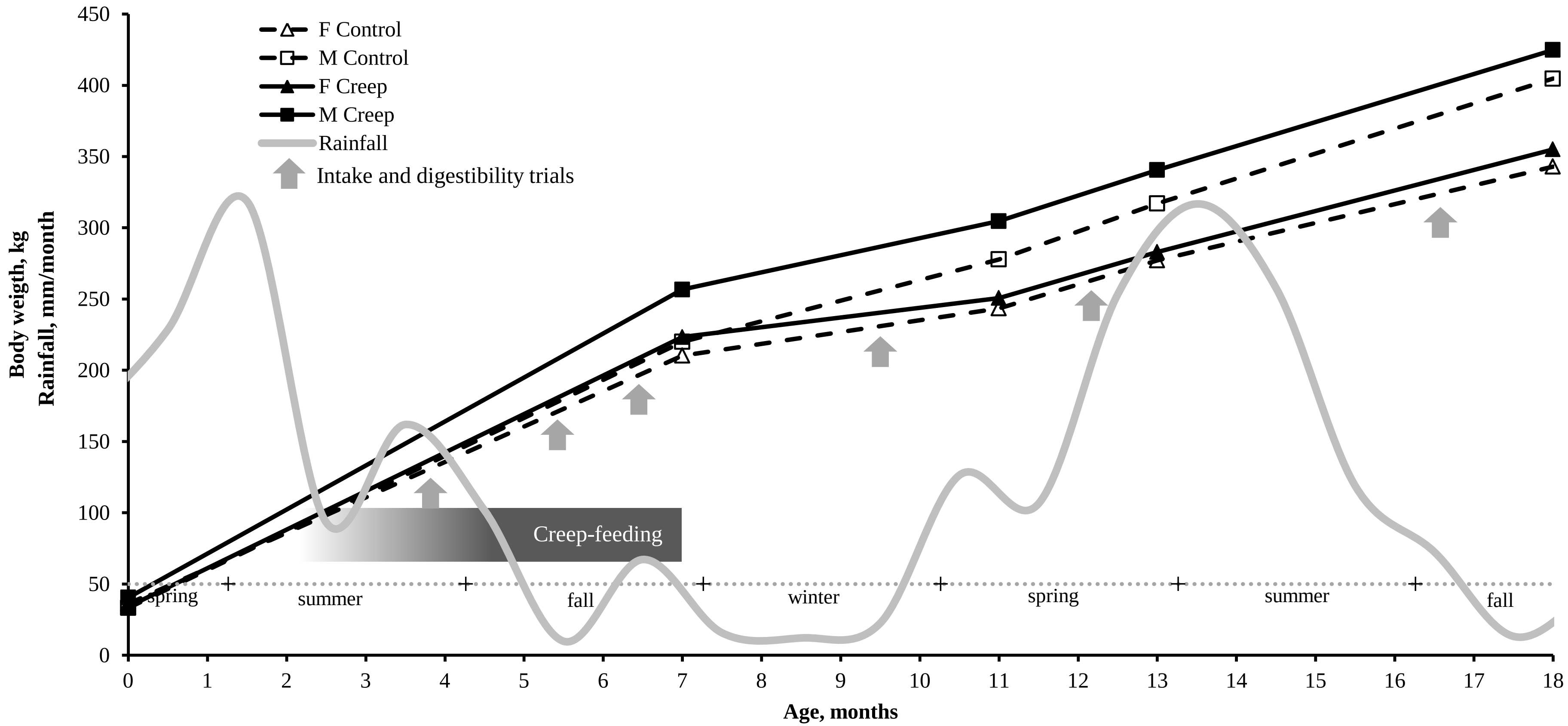

Figure 2: Graphical representation of the experiment (performance of animals, rainfall and intake and digestibility trials) under tropical conditions

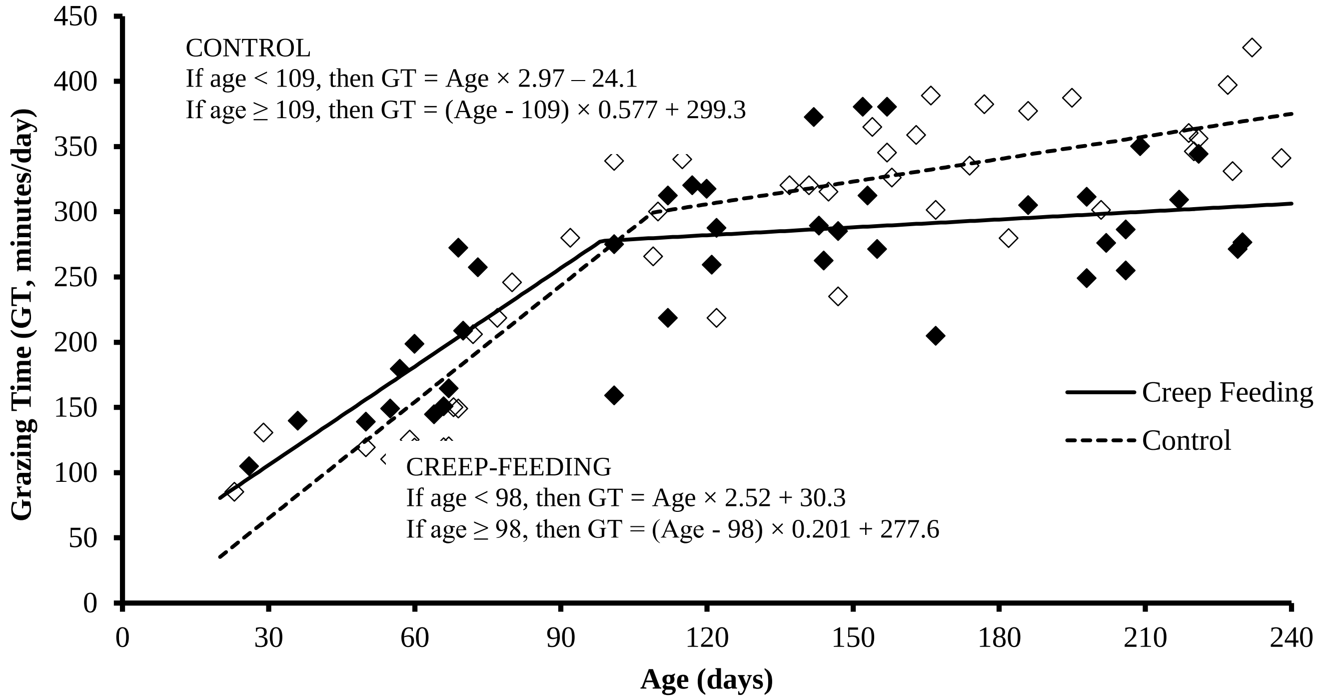

Figure 3: Relationship between grazing time and age of calves during suckling phase under tropical conditions

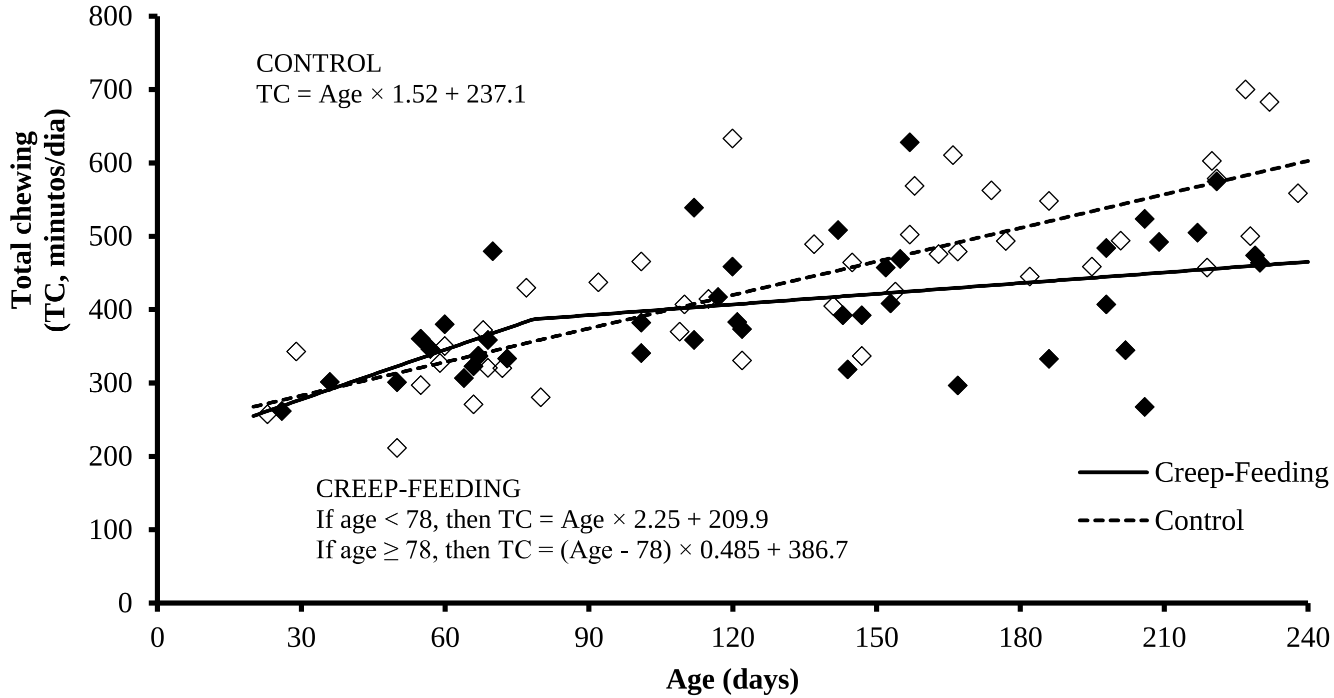

Figure 4: Relationship between total chewing and age of calves during suckling phase under tropical conditions